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THE GEOLOGY OF LUZON, P.I.

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INTRODUCTION

Luzon is the largest island of the Philippine group and, if not now, promises soon to be the most important island off the eastern coast of Asia. Because of its great strategic importance and because it is the home of the only Christianized people of Malay origin, it is of more than passing interest. Geologically, it is worthy of constant study as it is a link in that great "Circle of Fire" which girds the Pacific. From it, doubtless, are to be wrested

¹ Published with the permission of the Director, Bureau of Science, Manila.

important secrets relating to such questions as the former configuration of Asia, climatic changes, and possibly something of the early history of man. As a mining field, evidence is already abundant that Luzon will before many years have a place in the very first rank.

Finally, Manila, the capital of Luzon, through her Bureau of Science, an institution not surpassed anywhere in the Orient, will be the point from which, possibly, all the geology of the Orient will be correlated.

The dominant feature about Luzon, as is the case with other portions of the Archipelago, is the enormous coast line and the mountainous character of much of its interior. The effects on the character and pursuits of the people have been great. Some of these will be alluded to farther on in this paper. Luzon's geographical position is also noteworthy. She is in a region of tremendous rainfall (45 inches in 24 hours, Baguio Observatory record, July, 1911) and in the track of the most frequent and violent typhoons. As she extends from 10° to 21° north latitude and has much high level country, which is at the same time fertile, she could be colonized by white men.

PHYSIOGRAPHY

THE COASTAL PLAINS

The coastal plains about the Island of Luzon, are, as a rule, very narrow, the maximum width being about 10 miles. The mountains are nearly everywhere close to the sea. The best development of coastal plains is to be found north from Lingayen Gulf, because the northern part of Luzon has been longest under water, and erosion has had time to work on the mountains, carrying detritus down to the sea. The composition of the northern coastal plain consists almost entirely of alluvial and Piedmont deposits. Another fair development of coastal plain is found on both sides of the Tayabas Peninsula and around Batangas Bay. The east coast of Luzon is conspicuously lacking in broad coastal plains. It is a fact that the east coast is sinking in part, while the west coast is known to be rising in part. As evidence of this, I am citing the raised beaches and terraces along the Ilocos Norte coast on the

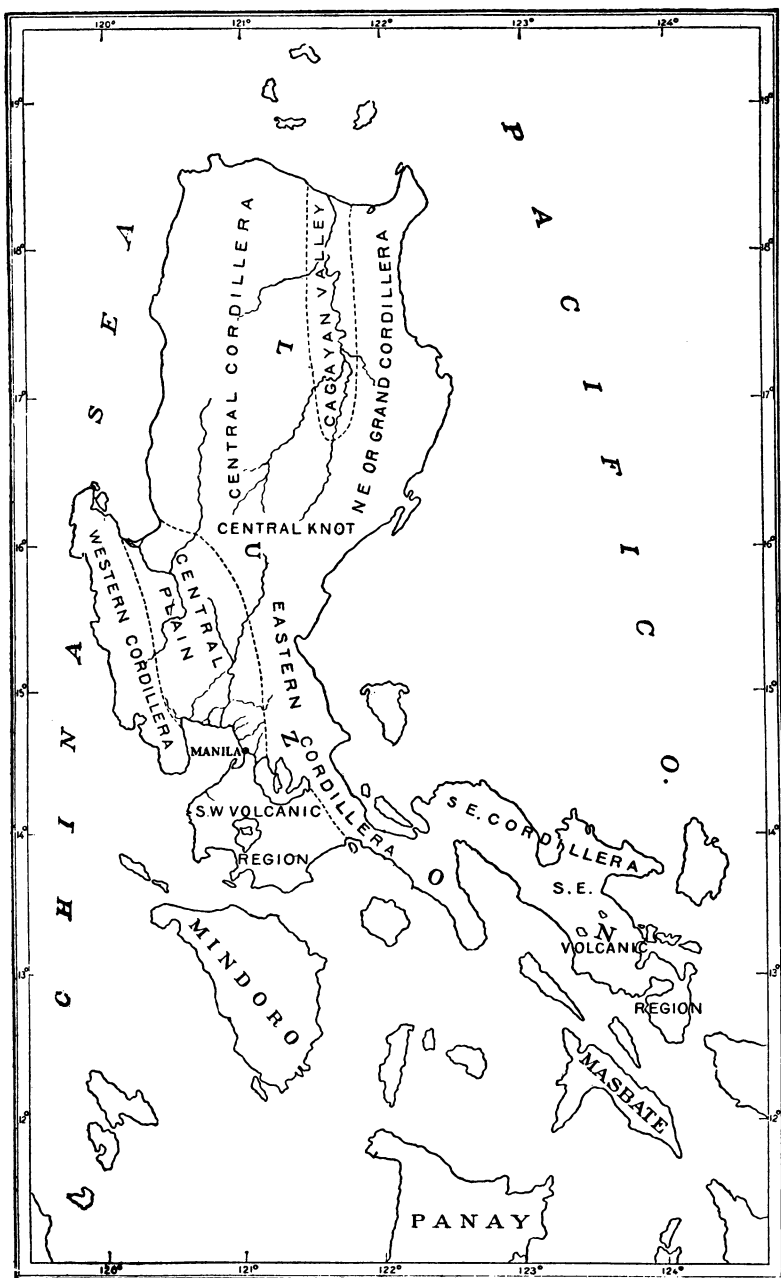


FIG. 1.—Map of Philippine Islands, (After Adams.)

west of Luzon, and the drowned river areas on the Camarines coast on the eastern side. We find extensive settlements on the western side of Luzon, on these coastal plains, the principal tribe being the Ilocanos, the members of which are perhaps the thriftiest and most energetic of all the tribes of the Philippines. These are the only people who produce all their own rice. On the eastern side of Luzon, the settlements are very, very scarce—in fact but little is known, or of the people north of Baler, except that they are not numerous.

THE CENTRAL PLAIN OF LUZON

The principal interior plain of Luzon is known as the Great Central Plain (Fig. 1) and is the chief place of settlement in the Philippine Islands. It is roughly, 120 miles long by 70 wide, stretching from Manila Bay on the south to Lingayen Gulf on the north. On the west, it is bounded by the Zambales Mountains, and on the east, by the Eastern Cordillera. This plain was probably the site of an ancient arm of the sea—a fact that has been called attention to by a number of geologists, among them Adams¹ who has drawn a hypothetical map of the Tertiary geography of the central portion of Luzon.

Composition.—In the northern and western portions this plain is largely composed of alluvial material, as shown by well-sections at Lingayen. In the southeastern part it is largely made up of pyroclastics, as can be seen in railroad and river cuts and numerous well-sections. That this pyroclastic material extended to a considerable depth is shown by the following well-section at Pasay near Manila:

SECTION OF WELL AT PASAY, RIZAL PROV., LUZON, P.I.

0	to	18	ft.	soil, sand, and seashells
18	"	83	"	gray and yellow silt with pebbles, shells, and calcareous concretions
83	"	87	"	fine to coarse basaltic pebbles and tuff
87	"	113	"	yellow-gray sand, some clay, fragments of soft tuff
113	"	160	"	yellow-gray tuff
160	"	180	"	yellow sand and tuff, small basaltic pebbles

¹ G. I. Adams, "Geological Reconnaissance of Southwestern Luzon," *Phil. Jour. Sci.*, V, No. 2.

180 to	463	ft.	light, yellow-gray tuff, partially with basaltic pebbles
463	"	483	" fine dark sand, some clear grains, tuff, basaltic pebbles
483	"	546	" fine grained tuff, light gray
546	"	570	" dark sand, some clear grains
570	"	594	" tuff, with small basaltic pebbles
594	"	634	" yellow clay with small basaltic pebbles
634	"	690	" dark sand
690	"	713	" fine gray tuff
713	"	743	" basaltic pebbles and fragments of tuff

Physiographic features.—At first glance, the most striking physiographic features of this plain are: (1) the drainage system; in the north the rivers flow to the north and in the south to the south; this is accounted for by warping; (2) the single extinct volcanic cone of Arayat, standing isolated in the center of this great flat; (3) the two large swamps and one lake located in the eastern part; (4) and the vast delta region of the Pampanga River which bounds Manila Bay on the north.

Farther along in this paper, I shall draw some conclusions regarding the human response to the physiographic and geologic conditions, showing how these features have controlled the human settlements, the intermingling of various tribes, and such like questions.

THE ALBAY PLAIN

We shall pass now to the second great interior plain, which is known as the Albay Plain (Southeastern Luzon). This plain is about as long as the one we have been considering, but is much narrower. It extends from Legaspi to San Miguel Bay. It is an old coastal plain, on the outer margin of which a volcanic cluster has been built up since this plain rose from the sea. The main drainage of this plain is to the north by way of the Bicol River. There are two or three small lakes which are little more than swamp-areas along the course of this river. To the west of this plain, the rocks are sedimentary, while to the east, as I have already said, they are recent extrusives. The material of this plain is largely made up of volcanic ash, boulders, bombs, lapilli, and tuff. This region is the principal hemp region of the Philippine Islands, and I believe that the peculiar composition of this volcanic soil is largely responsible for this.

THE INTERMEDIATE UPLANDS

All of the territory which is not coastal plain or central plain, and which is not above 5,000 feet in elevation, I shall designate as the Intermediate Uplands. Most of the highlands of Luzon will come in this category. Topographically it consists of the foothills and the sloping flanks of the high Cordilleras. The rocks may be of all classes, but the chief formations are the folded Tertiary sediments, limestones, sandstones, and shales, with the coal-measures, which slope away from the central ranges. Also the lower, and generally worn-down, volcanic stocks will be comprised under this heading.

The population in the Intermediate Uplands consists largely of the less progressive types and of more or less recent white settlers, prospectors, etc. In certain parts of Luzon, such as in Batangas and Laguna Provinces, where the underlying formation is a decomposing volcanic material and where the country is not too greatly dissected by streams, there is a fairly prosperous population, but in the uplands of northern Luzon very little advancement can be noted. There are scarcely any roads and there is very little communication between the different communities. The greater dissection of the country by the streams has decreased the area of agricultural land, and unless the mineral resources be developed, the country will always remain comparatively backward. The people who inhabit those sections give very little promise of ever being able to take advantage of the mineral resources as these are usually low grade and refractory.

THE CORDILLERAS

The eastern Cordillera.—The eastern Cordillera has a general north-and-south trend, but is marked by great sinuosities, following pretty closely the east coast of Luzon, so that in its southern extension where it cuts through Ambos Camarines, particularly in the Caramoan Peninsula, it is running almost east and west. Very little is known about the eastern Cordillera and but few prospectors have crossed it. Here and there in the northern part, some adventurous ones, notably Messrs. Heise and Dudley, crossed. Ickis (formerly a mining engineer in this Bureau) made a recon-

naissance from Laguna de Bay to Infanta, and Pratt and Adams have been on the Caramoan Peninsula. A few boats have skirted the east coast of Luzon, but very fragmentary observations have been brought back.

It is needless to say that we know very little about the elevation of this Cordillera, except that it is much lower than the central Cordillera, and in several places, to which I shall refer later, the range is quite low.

We know practically nothing about the formations in the northern part of this range. Ferguson found a volcanic peak, Mount Kawa, near the northernmost point. Ickis has made a cross-section from Tanay to Infanta (Fig. 5), showing closely folded sediments, diorite, and andesites. Adams and Pratt found considerable andesite in the central part of the range in Ambos Camarines.

If we examine the map showing the distribution of civilized and wild peoples, published in the second volume of the first Philippine Census, 1903, we note that the whole eastern Cordillera from Cape Engano to Casiguran Bay, and, except for two or three spots as far down as Infanta, is inhabited by Negritos. Then, continuing along the coast almost to San Miguel Bay, there is a long strip pretty well taken up by Tagalogs. Then, in the Caramoan Peninsula, the Negritos are found again with some Bicolos. At any rate the population is very scanty.

Beginning at the north, we find several well-defined passes through this range, and these passes are the location of trails leading from the interior to the coast. The first one runs from the headwaters of the Ilagan River eastward to Palanan Bay. Then about 50 miles south is another one leading across from the headwaters of the Cagayan River to Casiguran Bay. Only a few miles south of that is another which runs across from Cabanatuan to Baler. The next important pass is following the Chico River from Penaranda to Dingalen Bay. Farther south is the route followed by Ickis from Tanay on Laguna de Bay to Infanta. Another one extends from Pagsanjan to Mauban. Then from Lucena to Atimonan. In Ambos Camarines, this Cordillera splits up into two: one following as already described, the Caramoan Peninsula; the other stretch-

ing in a southeasterly direction down into Sorsogon, and this is crossed in two very important places—the first trail leads from Nueva Caceres to Pasacao, and the second from Albay to Pilar. These passes have been most important in the settlement of certain parts of the east coast. There has always been very little trading along the east coast and, by examining the map alluded to before, there are seen to be several isolated spots occupied by Tagalogs and it is my opinion that these Tagalogs have come across the mountains rather than by the longer way of the sea. From what we know of the history of the United States, mountains are great control-factors in the distribution of people. I have but to call attention to the Cumberland Gap leading from the Appalachian valleys into the “blue grass” regions of Kentucky and Tennessee. For a certain period in the history of the United States, practically the entire flow of the population was through this pass.

The central Cordillera.—The central Cordillera begins about the latitude of Lingayen Gulf and extends north to the northernmost point of Luzon. It is not a single range but consists of two or three parallel ranges. The eastern Cordillera and the central Cordillera start from what Adams calls the “central knot” which is the Caraballo Sur in northern Nueva Ecija. The principal range of this central Cordillera is the Polis Range about 25 miles east of Cervantes. In this range is Mount Polis or Amuyao, which is probably the highest peak in Luzon; Mount Data, which is 7,366 feet high, is another high peak in this Cordillera, and Mount Pulog east of the Agno River is also one of the highest points in the Philippine Islands (Fig. 2). On a recent trip into the northern country, I made a boiling-point observation on a peak 45 miles north of Baguio and found the elevation to be 8,236 feet, and there were a half-dozen peaks around me which were much higher. This Cordillera extends, as I have said, to the north coast, and keeps its high elevation practically throughout the whole extent. It is a region of great rainfall and steep slopes—much greater slopes than the material will stand on, so that landslides are of exceedingly frequent occurrence. The vegetation is very scanty, and practically the only forest tree is the pine (*P. insularis*).

The formations are largely igneous, diorite in the bottom of the

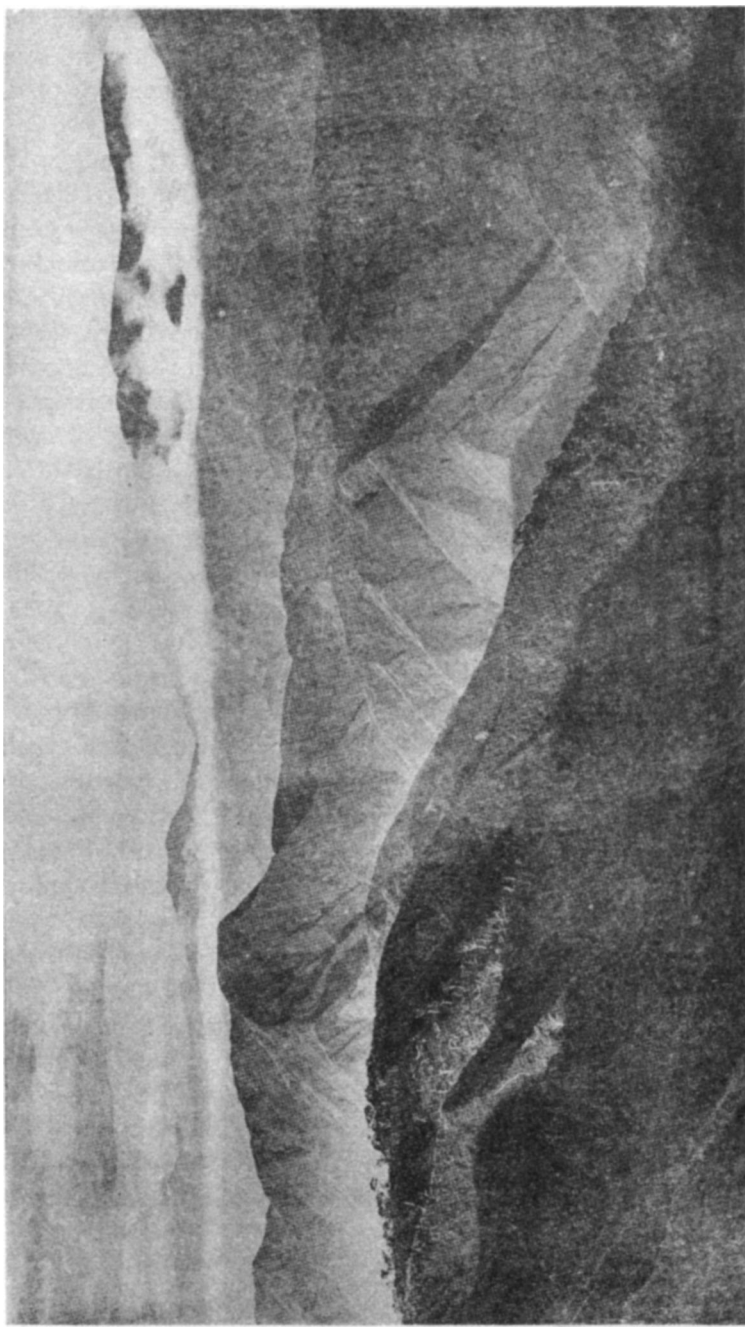


FIG. 2.—Topography in Cordillera Central of Luzon

canyon, and andesites on the upper slopes. There are no active volcanoes in this region but there are several extinct craters, and great areas of volcanic tuff. Around Baguio, the summer capital, there is a great deal of this material.

The population of this Cordillera is almost entirely made up of Igorots with the closely related tribes: Apayaos, Ifugaos, Ilongots, who are very scattered, and comparatively backward people, except in their knowledge of agriculture and irrigation. The Igorots of Lapanto practice the art of copper smelting (which was probably taught them by the Chinese) and with considerable success. The country is almost entirely without roads, but there are a great many Igorot trails which do not take any advantage whatever of the topography. The government, however, is building a horse trail which practically follows the backbone of the Cordillera for many hundred kilometers. It is proposed, in time, to make an automobile road out of this. Such a road will be of great benefit to the country and, already, there is a better feeling between these northern tribes and between them and the Philippine government.

As I said before, the Igorots take very little advantage of the topography; however there are several well-defined routes of travel; the principal one being the trail from Bontoc to Tuguegarao, from San Fernando to Baguio by the Naguilian trail and from Candon to Cervantes by way of Tiela Pass. From Tagudin to Cervantes and from Vigan across to Solano by way of the Abra and Chico rivers and then from Laoag across to the Abulog River by the Worcester trail. There is considerable travel by way of these routes, the passes being taken advantage of by the Ilocanos to go up into the Igorot country to trade. The Igorots, however, do not go down to the coast very much, and when they do, go usually for plunder or to buy dogs, which is one of their principal articles of diet. I do not know to what extent the Igorots use these passes. From my own knowledge of them it seems to make very little difference to them whether the road follows an easy grade or goes up and down hill; in fact they often take an up-and-down hill trail in preference to one on the level.

The western Cordillera.—The western Cordillera is generally known as the Zambales Range, extending from Olongapo north into Pangasinan Province. Another part of this range consists of a cluster of volcanic stocks in the Province of Bataan. This range of mountains is not by any means a continuous one—there being a few isolated high peaks—but in the main the range is not very elevated. The highest point in this range is Mount Pinatubo. This has never been accurately measured, but is in the neighborhood of 6,000 feet. Very little geological work has been done in this Cordillera. Von Drasche has done some work in the neighborhood of Iba, and Fanning has touched it in a few points in the neighborhood of Agno and Alaminos in Pangasinan, and I have been on the second highest peak of Pinatubo, about 5,500 feet; and also on one of the high peaks of Mount Mariveles, which is also about 5,000 feet high.

In general, the rocks of this range are volcanic extrusives, andesites, with marls and shales on the flanks. The Cinco Picos Range, however, on the western side of Subig Bay, consists of a totally different rock from that found on the east side, being a dense pyroxenite.¹ There are no active volcanoes along this line,² and the old volcanic stocks are pretty well eroded.

There is a considerable stretch of alluvial running from Subig northwest to San Narciso. This stretch of country here is very dry in certain seasons, and owing to the composition of the soil the water sinks in rapidly and the whole appearance of the country is very much like that of the desert in the western part of the United States—particularly on the western slope of Pinatubo. For a

¹ The effect of the geology upon geodetic calculations was very effectively demonstrated recently in this part of Luzon. A considerable discrepancy between the astronomically determined points and the trigonometric stations near Olongapo was found to exist. The small Cinco Picos Range, which consists of pyroxenite, lies to the west of the stations and the great andesitic mass of the Zambales to the eastward. The observers expected the plumb bob to be deflected in an easterly direction owing to the main mountain mass being to the east, but the deflection was in the opposite direction toward the smaller mass. Not until an examination disclosed the denser rock in the Cinco Picos (to the west) could the discrepancy be explained.

² It was reported by Mr. Snyder of the Bureau of Lands that smoke was seen issuing from the top of one of these peaks.

more detailed description of this country, the reader is referred to Vol. IV, sec. A, No. 1, p. 19 of *The Philippine Journal of Science*; "Contributions to the Physiography of the Philippine Islands," IV, W. D. Smith.

We have, more or less, general notes on the population of this region but our main source of information comes from Reed who wrote quite extensively on the Negritos of Zambales. These people are pretty much the same as the Negritos of other parts of the Island, and make up a very much scattered and nomadic tribe.

The principal pass across this region is from O'Donnell in the Central Plain, to Iba. The government has built a road, within recent years, between these points.

There is another well-defined trail from Mangatarem across to Infanta at the southern end of Dasol Bay.

There is also a good road from Alaminos to San Isidro, and in the southern part there is a telegraph line from Olongapo to Dinalupijan. With the exceptions of the use by the natives and occasional expeditions of U.S. Marines, this trail is very little used.

The northern Zambales are not covered with a particularly heavy growth of timber; in fact, many parts, like Pinatubo are quite bare up to about 5,000 feet—the last 1,000 feet being covered with a dense mossy forest; this is due to the excessive moisture from the clouds which continually hang about the summits. In Bataan Province, the vegetation is very dense and the forests possess considerable commercial value. The Cinco Picos Range, however, is almost bare.

The southeastern volcanic cluster.—In northern Ambos Camarines, as I have already mentioned, the Cordillera bifurcates: one fork running through the Caramoan Peninsula, and the other following the west coast. Between these two in what was originally a more or less level plain, there has been built up a cluster of volcanic cones more or less dissected by erosion. However, there is one very perfect cone, Mount Mayon, which is probably the most perfect volcanic cone in the world. This is the highest of the group, and is only a short distance from Legaspi. What must have been a larger cone at one time, is now represented by Mount Isarog; but the symmetry of this has been destroyed by one side of the

mountain sliding out, so that there is a great gap in the crater on one side. In spite of the great size of these mountains and the deep canyons on their slopes, they are of very recent origin. Recently Adams, who made a trip through that country, has compiled all of the various reports in a very interesting and able discussion in his "Geological Reconnaissance of Southeastern Luzon," which is found in Vol. VI, No. 6, *Philippine Journal of Science*. Of all the travelers through this district, Martin, the government photographer, is the only one who has brought back good photographic records.

In 1909, Mr. Martin and a Franciscan Father from the town of Tobacco, made an ascent of Mount Mayon and secured fine pictures of the crater and of the country as seen from the crater. The most interesting point in connection with Mount Mayon, is, that the curve of its slope is so perfect that it can be represented by the formula for the sine curve:

$$\frac{4}{c} = \frac{e^{-x/c} - e^{-x/c}}{2}$$

when $c = 8.6$ mm.

This was worked out by Dr. G. F. Becker of the U.S. Geological Survey, who made a geological reconnaissance of that region in 1901.

An extensive population is found at the foot of these mountains, but in the higher parts there are only a few Negritos.

This district is one of the finest in the Islands, from a scenic point of view, as well as agriculturally, and occasionally, as in 1900, very spectacular eruptions take place from Mount Mayon.

Further south in Sorsogon is another large dissected volcanic stock called Mount Bulusan. This is very much like Mount Isarog in general appearance.

THE RIVERS

There is a host of rivers of all sizes in Luzon. I shall, however, refer to eleven only. The largest river is the Cagayan in the northern part of the island, the shortest, perhaps, is the Pasig, but from a human standpoint, the Pasig is by far the most important of all.

The Cagayan.—This river rises at about latitude 16° , and empties at Aparri, N. $18^{\circ} 30'$. Apart from local sinuosities it is a remarkably straight river, leading one to believe that it must follow some

structural line. This river is navigable up to Ilagan, and along its banks are located the principal tobacco fields of the Islands. At Aparri considerable difficulty is experienced from the formation of bars crossing the river mouth. The insular government is spending considerable money in keeping this channel open. This stream flows in a very wide, level plain and the soil is remarkably rich.

The Pampanga.—The second largest river of Luzon is the Pampanga. This river rises in the Caraballo Sur Mountains or in the "Central Knot," and flows somewhat west of south and debouches into Manila Bay, by means of a myriad of channels. This river is navigable for a long distance into the interior, and is one of the principal highways of commerce in Luzon.

The Agno.—The Agno river rises on the slopes of Mount Data in north central Luzon, and flows due south until it reaches the Pangasinan Plain where it turns sharply to the northwest and empties into Lingayen Gulf. This river is navigable for a short distance from its mouth, but in the mountain district is simply a roaring torrent washing along big bowlders, and is not at all navigable. This river overflowed its banks twice during 1911, flooding a large section of Pangasinan Province.

The Abra.—The Abra rises also on the slopes of Mount Data, then turns abruptly to the north, flowing for 40 miles or more until it gets to the town of Dolores, where it makes another very sharp bend and flows southwest, emptying into the ocean near Vigan. This river throughout a great deal of its extent is located in a deep gorge. Very little is known of the geology along its course.

The Bicol River.—The Bicol River where it rises due west of Daraga is known as the Kinali River. Thence it flows northwest along the Albay central plain, through one lake (Lake Bato) and a large swamp, finally emptying into San Miguel Bay. This river is navigable almost to Bato Lake. It very frequently overflows, and for this reason, the district through which it flows is one of the principal rice districts of the Islands.

The Angat River.—The Angat River is referred to here more on account of its length, than for any other reason. It rises in the Eastern Cordillera, flowing with considerable sinuosity westward, and empties into the Kingwa River which also flows across the

Bulacan Delta into Manila Bay. This river is not navigable to any great extent, but at Noñzagaray the river has some falls where considerable power could be obtained.

The Bued River.—The next river in point of size is the Bued River, which, while much shorter than the Agno, flows in the same direction, and is only mentioned here, because of its connection with the famous Benguet Road. This river is probably responsible for more damage to the works of man than any other river in Luzon.

During the summer of 1911, it was the scene of a very destructive flood, which was due to a cloudburst, near Baguio. Thirty-seven inches of rain fell in twenty-four hours in Baguio. The larger part of this water flowed into the Bued River Canyon, and at the lower end, there occurred a great landslide which dammed the stream to a height of 60 feet. When this dam broke, a large portion of the lower end of the Benguet Road was washed out into the Pangasinan Plain. This road has suffered repeatedly from these floods.

The Pasig River.—The Pasig is a very short river, 15 miles, very deep and of moderate width, and is the outlet of Laguna de Bay. It is important mainly because of the great volume of commerce which travels along it, and for the fact that the capital of the Archipelago is situated at its mouth. This river is tidal in its lower section, about up to Fort McKinley. From here on to the lake, it is much narrower and quite shallow in places. The river has a very treacherous current.

The Paracale River.—The Paracale River is mentioned here not on account of its size, but because it is distinguished by two very important features. The most important is that it is probably the richest river of all, there having been discovered considerable stretches of rich gold placers along its course. From a physiographic point of view, it is interesting, because, in its lower portion, this river is a drowned river. It has long been known that the Camarines coast is subsiding.

THE LAKES AND SWAMPS

The true lakes in Luzon are first and foremost, Laguna de Bay; second, Taal Lake; third, Laguna de Canaren, Bato and Buhi, while the following, Paway, Cagayan, Pamplona, Mangabol, and Candaba are merely great swampy areas, whose size changes with the seasons.

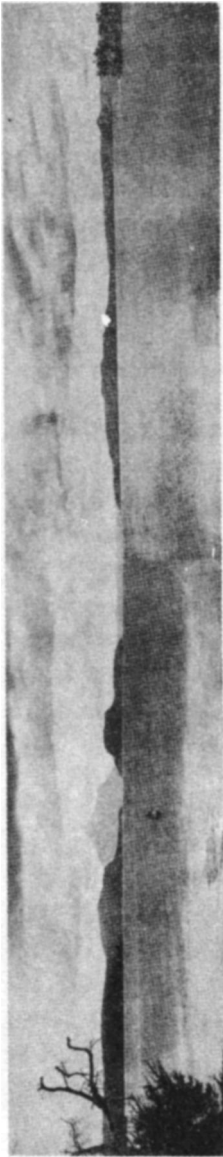


FIG. 3.—Taal Lake; Taal Volcano on low island in right background

In his study of the Southwestern Luzon region, Adams has discussed the two first-named bodies.¹

Laguna de Bay is a heart-shaped body of water with two prongs of land projecting into it from the north side. It lies a short distance southeast of Manila, and is separated from Manila Bay by about 6 miles of land. Its dimensions are 25 by 28 miles. It is fairly shallow. The height above sea-level varies between 0.9 and 4.3 feet.

Taal Lake.—The second largest lake in Luzon is Taal Lake or Laguna de Bombon (Fig. 3). This has generally been regarded as a crater lake by such writers as von Drasche and Becker, but Adams who has perhaps given more time and study to it than any other, attributes the origin of the lake to peripheral faulting. My own opinion is that the lake has originated through (1) peripheral faulting, (2) explosion of a former and much larger volcano than now exists there, and (3) subsequent collapse of the crater area (Fig. 4).

For details about this lake and volcano, I shall merely refer the reader to the three most exhaustive articles on this subject.²

THE HUMAN RESPONSE TO PHYSIOGRAPHIC CONDITIONS

The relationship between man's work and physiography, has long been emphasized by many writers. Although this relationship has often been over-estimated,

¹ G. I. Adams, "Geologic Reconnaissance of Southwestern Luzon," *Philippine Journal of Science*, V, No. 2.

² G. I. Adams, *op. cit.*; W. E. Pratt, "Eruption of Taal Volcano," *Philippine Journal of Science*, VI, No. 2; D. C. Worcester, in *National Geographic Magazine*, 1912.

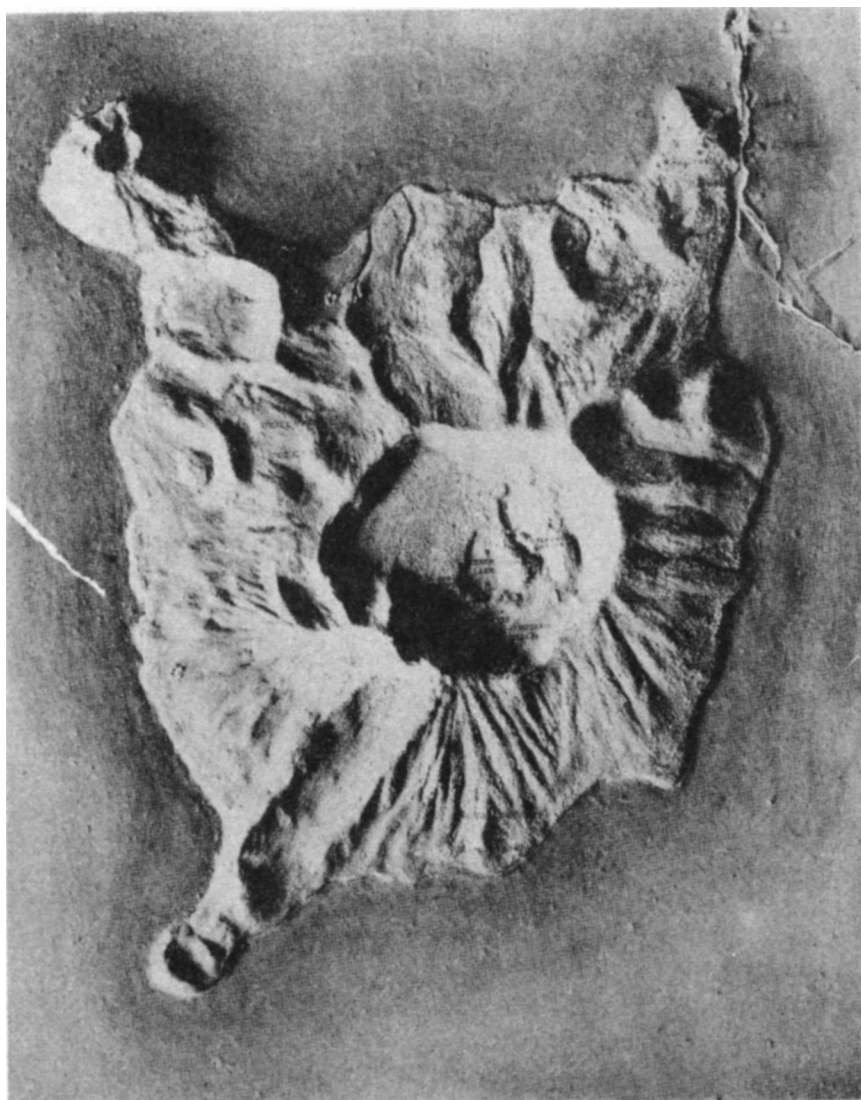


FIG. 4.—Photograph of model of Taal Crater as it was before the great eruption of January, 1911.

many things having been explained as due to the topography of the country that have really been very little affected by it, still it is certain that physiography is a factor of considerable importance. We know as yet too little about the wild tribes of the Philippines and too little of the topography of the country, in some parts, to make it safe to dogmatize much at this time. However, a few general statements may be made, which are to be taken as tentative, and (like a railroad schedule) are subject to change.

If we examine again the census map alluded to above, we note that there are certain dominant tribes in Luzon. In the north central region, the part occupied by the Cordillera Central, the dominant tribe is Igorot. In only one place does he come down to the coast, and that is where the Cordillera itself reaches the coast.

Next to this tribe, and almost completely hemming it in, are the Ilocanos, a rapidly increasing tribe and probably the most virile of all the tribes in the Philippines. It occupies the Coastal Plain, but has already gained a foothold in the Central Plain. Since the opening up of new roads and trails in the mountainous area, he has begun to wedge his way into the territory of the Igorot.

Occupying the "Central Knot" and adjacent mountainous country, we find the Ilongots.

The Negrito has been pushed back into the more or less unknown and inaccessible tracts, such as the Zambales and the southern Cordilleras.

Surrounding Manila Bay and extending down into Tayabas, we find the Tagalog. It is yet too early to state definitely, but it would seem that the Tagalog is becoming more and more restricted.

The southeastern peninsula is occupied almost exclusively by the Bicol, but here again in the almost inaccessible parts are to be found the Negritos.

Around Lingayen Gulf there is a small area occupied by the sub-tribe known as Pangasinans.

A recent writer on ethnological subjects says, that if a Bontoc were dressed in the clothes of the Tagalog and the Tagalog (un-) dressed like the Bontoc, it would be very difficult to note the difference. This is my own opinion about these people and I believe that the differences are very superficial. As soon as the

railroad and the school have had a chance to work on these people and mix them up, the tribal characteristics will largely disappear. At the present time it seems that the following characteristics may be noted with reference to the different tribes:

The Ilocano lives on the Coastal Plain and spends a great deal of his time at sea, as the Coastal Plain is too narrow to furnish all of the food necessary. He is, because of this life a nomadic individual and has therefore been able to penetrate farther into the other districts in Luzon. I expect to see this tribe, in time, dominate Luzon.

The Igorot is a much stockier man than the Ilocano, and shows, in his build, the effect of his hill-climbing life. Due to the mountain barriers, he has been kept more isolated and has to spend more time getting his food, and therefore is more of a stay-at-home. Many of the Igorots will not leave their own communities, being afraid to go from one town to another. The government is dispelling this vague fear of the Igorot, and many barbarous customs, such as head-hunting, are fast becoming obsolete. It is believed that the physiography of the country has had a direct and very important effect upon the people. Traveling in that country is a serious matter, and they will not take the trail, unless they are very hungry or some other inducement is offered.

The Negrito is very evidently a vanishing tribe. The government by its paternalism may for a time postpone the extinction of these people, but the arrest in their development seems to have been so complete that it is a question whether they can ever recover, or whether it would be of any particular value to the human race for them to recover. The writer has been among these people, and while he has seen some signs of an organized life, it is a hand-to-mouth existence, and they are often little better than animals. They are exceedingly shy and one may travel for days at a time through their country without seeing anyone.

The Tagalogs are the most advanced in western civilization, of all the tribes of Luzon, and a glance at the map will show how they have clustered about the capital of the Archipelago. Physically not much can be said of them. They do not produce very much of their own food, being mainly engaged in the more sedentary pro-

fessions. Whether the new form of education being introduced into the Philippine Islands will regenerate them, remains to be seen. It is a notable thing that they occupy only about one-third of the Central Plain of Luzon. The Ilocano, Pangasinan, and the Pampangan are fast crowding them back toward Manila. Some might argue that physiographical conditions are responsible for the political dominance of the Tagalog. But this connection is only an indirect one. The chief Spanish settlement of the Archipelago has always been Manila. Of course, Manila's situation depended upon physiographic features, and the Tagalogs happened to be where the Spaniards first settled, and in that way they have obtained their political pre-eminence, but it has been rather through the relationship to the Spaniard, than to the fact that he is living along the Pasig River and around Manila Bay.

The Bicol is a hard-working and very peace-loving individual, and is a man of the fields. It is not believed, however, that he will materially increase his present range.

Another tribe which appears to be peculiarly influenced in its habitat by physiographic conditions, is the Cagayanese. He is confined exclusively to the Cagayan Valley and the Batanes and Babuyan Islands directly north of Luzon.

We also note another feature in connection with the distribution of tribes: that the densely forested areas are occupied by the Negritos, the forests furnishing additional means of concealment.

What future changes will take place in the distribution of these people can only be conjectured. It is my opinion, that the Tagalog will follow new railroads and new highways. The Ilocano will probably dominate all of the lowlands, because he is a great rice grower. The Bicol will probably remain stationary, and the great stretch of country now covered by the Igorot will be criss-crossed by the paths of the Ilocano. All through this population will be found scattered, the Chinaman, as in all the countries of the Orient. He is not a producer, however, but occupies in the Malay world the same place as the Jew in the Western World. Outside of the large cities, the Chinaman controls the trade. As the government has placed severe restrictions upon the Chinaman, he is not now a very important factor. He affects the population to a certain extent,

by intermarriage with the natives, but the Chinaman as a Chinaman need not be considered further in this article.

GEOLOGY

GENERAL CONSIDERATIONS

If we examine the general geological map of the Island of Luzon, we distinguish in the southern part, a rough lining up of formations into belts or long strips having a northwest-southeast trend.

First, at the extreme southeast, there is a zone of metamorphic rocks beginning on the small island of Rapu-rapu and extending northward through Ambos Camarines in the vicinity of Mambulao. Their continuation will undoubtedly be picked up some day along the east coast of Luzon, farther north.

Next, to the westward, is a belt of recent volcanics. In this belt, are the well-known cones of Bulsan, Mayon, Iriga, Isarog, and the pretty well worn-down stock of Bagacay.

Third, the narrow Albay Plain.

Fourth, a broader belt of folded sediments in the western part of the Sorsogan peninsula, and constituting practically the whole of Tayabas peninsula. This belt continues up into Central Luzon, where it becomes partially concealed by later volcanic flows.

Fifth, another volcanic zone which takes in Taal, Talim and Arayat, in the eastern portion of the Central Plain.

Sixth, the plain belt, beginning with the Cavite Plain and the Central Plain, extending north to Lingayan gulf.

Seventh, the line of andesite stocks constituting the Zambales.

Eighth and westernmost, the very basic and dense rocks of the Cinco Picos range, just west of Subig Bay. This last is really almost insignificant in area, but very important as has already been mentioned.

In the northern part, we cannot, as yet, make such clean-cut separations, owing largely to our ignorance. However, a rude parallelism of belts can be made out.

Having considered the distribution of formations geographically, let us now turn to a consideration of the stratigraphic sequence; this is best shown by the tabular scheme in Table 1.

The absence of older formations than the Tertiary from this column may be explained by one or more facts, namely:

TABULATED SCHEME OF STRATIGRAPHY

Period	Formation	Type Locality	Distribution	Economic deposit	Characteristic fossil
Recent	Coral reefs Littoral deposits Volcanic tuff	Cebu Sangley Point Vicinity of Manila	Along much of the Philippine coast line Southern Luzon, Ilocos Norte	Building stone and lime Sand "Guadalupe" stone for building	Leaves, probably belong to <i>Euphorbiaceae</i>
Unconformity	Basalt and andesite flows	Mount Arayat and Mount Apo			<i>Hindia dijiki</i> Mart.
Pleistocene and Pliocene	Raised coral reefs Marls Eruptives	Cebu, west coast Ilocos Norte Mount Mariveles	Cebu, northwestern Luzon Samar, Agusan River Mindanao, Luzon, etc.		
Unconformity					
Miocene	Limestone—upper	Cebu		Burned for lime, very pure	Shells very similar to recent forms; chiefly coral reefs
Unconformity	Andesite flows	Do	Cebu, Masbate, etc.	Gold, silver, manganese, lead	<i>Lepidocyclus insular-natalis</i> Chap.; <i>Lithothamnium ramosissimum</i> Reuss; <i>Cyclodypaeus communis</i> ; <i>Orbicolites</i> , etc.
Miocene	Limestone—middle	Do	Cebu, central Luzon, southwestern Luzon, north Mindanao, east Mindanao, Romblon	Romblon marble, Montalban limestone	<i>Arcas</i> , <i>Callianassa dijiki</i> Jenk.; <i>Vicarya callosa</i> Jenk. <i>Nummulites niasi</i> Verb.
Miocene	Sandstone Shale	Batán Island Do		Oil in Tayabas and Cebu Coal deposits, Cebu, Batán, Polillo, Masbate Mindanao, Luzon, etc.	
Oligocene	Limestone—lower Crystalline schists, granite, gneisses	Cebu, Batán Island Camarines	Camarines, Ilocos Norte, Cebu, Zamboanga Peninsula, Romblon Island	Gold, mica, talc, apatite, hematite, magnetite	
Unconformity (?)	Iron formation Radiolarian cherts	Bulacan Ilocos Norte			Sponge spicules and fragments of Radiolarian tests
Pre-Tertiary (?)	Quartz porphyry Diorites Gabbros Pyroxenite Peridotite	Lepanto Benguet Leyte Ilocos Norte Near Olongapo	Central and northern Luzon Northern Luzon, Leyte, Panay Leyte, Mindanao, etc. Ilocos Norte, Zambales Mountains, Batán Island	Copper ores Gold tellurium, silver Serpentine and asbestos	

1. Very little exploration has been carried on in the dissected areas of northern Luzon, where we would expect to find the older formations.

2. The Philippine Islands are situated at the outer edge of the Continental shelf, where the sediments are all recent and the older rocks would naturally be very deeply buried.

3. Erosion has not as yet progressed very far, owing to the comparatively short period that the archipelago has been above the sea.

Below are given two sections across Luzon at different latitudes (Fig. 5. Infanta to Tanay [Ickis], and Fig. 6. North Central Luzon [Eveland]).

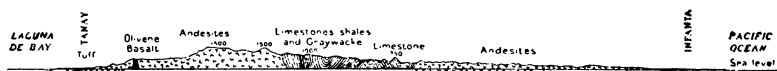


FIG. 5.—Section from Laguna de Bay to the Pacific. (After Ickis.)

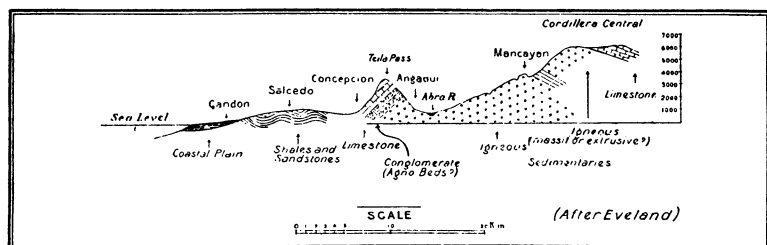


FIG. 6.—Section across North Central Luzon. (Eveland.)

THE IGNEOUS COMPLEX

By the igneous complex, we mean all those igneous rocks overlaid by the tertiary sediments, some of these are diorites, some andesite and diorite intrusions and others are granites. They are naturally encountered over larger areas in northern Luzon, where erosion has been at work longer and more vigorously. The central Cordillera then is the principal habitat, if we may use the term in this connection, of this class of rocks. Farther south, particularly in the vicinity of Manila, these rocks are deeply buried and only appear in isolated localities as in Ambos Camarines, the Loboo Mountains of Batangas, etc.

Diorite, quartz diorites, metadiorites, granites, gabbros are all found in Luzon. Diorite is the commonest deep-seated rock.

There is complete gradation from this rock into andesite, the difference between the two being chiefly one of depth and hence rate of cooling of the original magna.

As Professor Iddings has worked over most of the rocks in our Philippine collection, I shall refer the reader to his descriptions of these rocks.¹

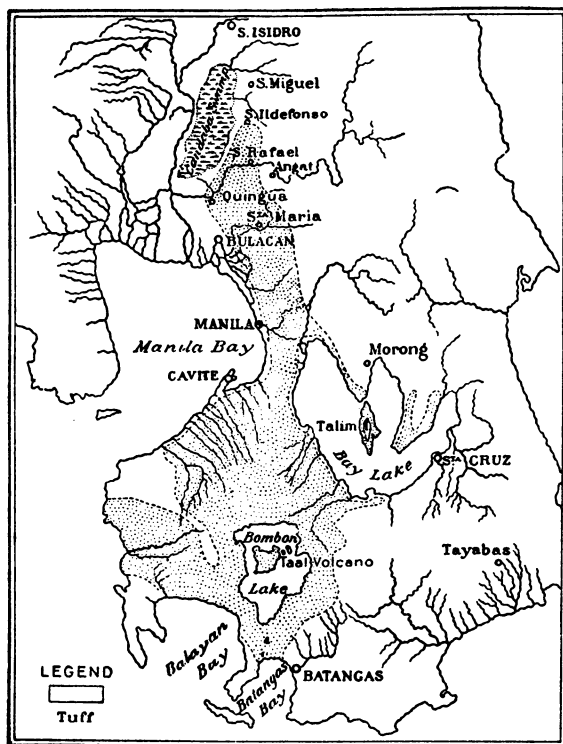


FIG. 7.—Map of Southwestern Luzon. (After Centeno.)

The extrusives.—As far as we now know, the andesites form the more or less worn-down volcanic stocks, and the basalts represent distinctly later flows. The andesites and basalts are generally fairly uniform, but we have besides, vast areas of volcanic agglomerates grading from a formation made up of large blocks more or less angular and somewhat scoriaceous, to a rather fine-grained tuff.

¹ J. P. Iddings, "Petrography of Some Igneous Rocks of the Philippines," *Phil. Jour. Sci.*, V, No. 2, 155.

Iddings, Oebbeke, and the writer have described specimens of these rocks from various parts of the Islands, but Iddings is the only one who has attempted anything like a systematic study of them, with a view of drawing conclusions concerning petrographic provinces, correlation, etc. He found that pyroxene andesites with hypersthene and augite both present predominate, next hornblende-pyroxene andesites, and third, hornblende andesites without pyroxenes, and last, a few with biotite in addition to the minerals already named.

There is a complete gradation from the andesites to the basalts. Some of the latter are extremely rich in olivine.

Dacites have been found in a few localities, Corregidor Island at the entrance to Manila Bay being the type locality.

The greatest distribution of agglomerates and tuffs is to be found in the region of Laguna de Bay and over a large part of Batangas Province (Fig. 7).¹ The agglomerates are especially well shown in a deep and very picturesque gorge at Pagsanjan, Laguna, and from there all the way to Mount Banajao, one finds nothing but volcanic agglomerate with patches of tuff here and there. This tuff and agglomerate have been more particularly discussed by Adams in the article already referred to.

THE METAMORPHIC ROCKS

Metamorphic rocks have been found in Ilocos Norte, in Ambos Camarines and in Benguet, probably in many other parts they will be found when more exploration has been carried on.

In Ilocos Norte, we have actinolite and mica schists, bordering a granulite dike, in Benguet marble, due to diorite intrusion, in Ambos Camarines gneissic granite and schistose diorite.

The rocks of the volcanic mountains are by far the most widely distributed¹ of all the rocks in Southern Luzon, and possibly in the Island as a whole. The country surrounding Manila and southwestern Luzon is the principal home of these rocks. The chief centers are Arayat, Taal and Banahao, Mariveles, and the southwestern volcanic cluster. The principal rocks are andesites with later flows of basalt.

¹ For general distribution of the major formations the reader is referred to the map in *Regionale Geologie* (Steinmann in Bonn), VI, pt. 5, by Warren D. Smith.

THE TERTIARY SEDIMENTS

We have found in Luzon, so far, no sediments known with certainty to be older than the Tertiary. In Ambos Camarines, there is a brecciated sandstone, and a shale, which some have thought to be older, but fossil evidence is entirely lacking. In Ilocos Norte, on the Baruyan River, I found some outcrops of a very red brecciated jasper, which may represent a Jurassic formation. I made thin sections of this rock, and, while I made out no definite fossil forms, Dr. Karl Martin of the Reichsmuseum in Leyden, who examined them, said he could distinguish the remains of sponge spicules, and fragments of radiolarians, and he was of the opinion that the rock was very similar to specimens he had found in the Moluccas and which he had called Jurassic. These are exceptional and isolated cases. The main bulk of the marine sediments of Luzon are Tertiary sandstones, shales, and limestones. The sandstone is usually a fine to coarse-grained grey rock which is very impure, having, as a rule, more feldspar and ferromagnesian than quartz fragments. Just how thick it is, we have never been able to determine, through lack of good sections. It probably varies from 60 to 325 feet in thickness. The shales are bluish-black to light yellow, very fine-grained, and generally low in silica. There is every gradation between the sandstone and the shale. The shales lie over and above the coal seams at nearly all the outcrops. How thick these are, we do not know exactly. They usually are very thin-bedded and are not very consolidated. Above the sandstones we find a hard, white, crystalline limestone which contains abundant remains of foraminifera—the principal genus being *orbitoides*. Below, I insert Professor Douvillé's classification of the Philippine Tertiary, as worked up from material which I furnished him in 1908. This table (Table II) may fairly well represent the stratigraphy of Luzon. The uppermost limestone is noteworthy for its purity, as it has been changed very little since its formation in the sea. Coral remains are very abundant in many parts of it, in fact at an elevation of nearly 5,000 feet in Benguet we find a fossil coral reef containing fragments of many species of coral, most of which are now growing in the China Sea.

TABLE II

(AFTER DOUVILLÉ)

	Philippines			Borneo	
c	Upper limestone with small Lepidocyclines	<i>Lep. c.f. Verbeeki mio- gypsina</i>	H	Burdigalien	Miocene
2 b	Sandstone and shale	<i>Clycoclypeus commu- nis, Orbitolites alveo- linella Miogypsina</i>	G F	Aquitanién	
a	Middle limestone with large lepidocyclines	<i>Lep. insulæ-natalis, formosa, richthofeni</i>	E		
1	Lower limestone with nummulites, Coal Measures	<i>Nummulites niasi Verb., Amphiste- gina c.f. Niasi, Le- pidocyclina</i>	D	Stampien	Upper Oli- gocene

RECENT FORMATIONS

Under the recent formations, I shall take up the following: (a) Piedmont deposits; (b) coral reefs; (c) pyroclastics; (d) placers; (e) laterite, and products of weathering.

In a region of such tremendous rainfall, such as we have in the Philippine Islands (45 inches in twenty-four hours, recorded at the Baguio Observatory, Mountain Province, Luzon, July, 1911), probably nowhere exceeded save possibly at Simla in India, it is natural to expect great erosion in the high levels, and a deposition of the eroded material in great volume at the foot of the mountains. Such deposits can be found in Pangasinan Province, where the Agno and Bued River flow out onto the Central Plain, and along the western coast in the Ilocano Provinces. A great deal of the coastal plain of Ilocos Norte and Ilocos Sur is built up by this wash material, brought down by the short and rapid mountain streams. A great deal of this deposit consists of huge boulders which are of considerable annoyance to farmers, and are serious obstacles to gold dredging, but with these boulders comes down great quantities of finer material, which must play a great part in enriching the soil.

Coral reefs.—An examination of the coast and geodetic charts now issued for the coast-line of Luzon, show that there are great stretches of coral reefs. They are very important not only from the point of view of navigation, but they represent the foundation for the lateral growth of the island-mass. My own observations on the west coast of Luzon reveal the fact that much of that coast is now rising, and as the coral reefs grow up to a limiting plain—the

surface of the water—they naturally present, when elevated, a more or less flat platform upon which the rivers deposit their loads and in that way build up new land. On the east coast, it is not so easy to see this growth, as throughout much of its extent, the coast is sinking: witness the drowned river-mouths of the Paracale and other important rivers.

The Pyroclastics.—The present eruptions and those of the Pleistocene have generally been marked by great quantities of ash and rarely by out-pourings of lava. A great deal of this material happened to fall into the sea or other bodies of water and was subjected to a sorting process and as a result, we get the great beds of tuff so well developed adjacent to Manila. These beds alternate with marine sands showing rapidly changing conditions.

This tuff has been experimented with and found to be of practical value in the making of a variety of sandlime brick.

The greatest development of this, as has already been mentioned, is around Laguna de Bay, near Manila.

Placers.—On the east coast of Luzon in the vicinity of Paracale, Ambos Camarines, there is a considerable development of rich placer ground. The country is notable for the great number of “stringers,” rich in gold, most of which are too small to work on an extensive scale, but where they have been eroded and the detritus has become concentrated in pockets in some of the “drowned,” valleys on that coast, some remarkably rich ground has resulted. Gold and native copper as well as galena and sphalerite are found in them.

In the streams near Manila, principally the Mariquina, some platinum has been found. Along the Bued River also are promising placers.

Laterite, etc.—Naturally the action of weathering in the tropics is very important and very pronounced, but on the higher lands, it is not always so evident, because the tremendous rainfall quickly removes any unusual accumulation of material.

The great development of ferro-magnesian minerals in the igneous rocks, results in an extensive accumulation of iron rich soil on the lower slopes, and this is so often like the deposit known as laterite, as to merit special mention as a distinct formation.

Much that passes as laterite in the East is undoubtedly merely a product of weathering of rocks, in place, though it is recognized that there is more than one mode of origin.

ECONOMIC

COAL

No workable coal seams have been yet opened upon the Island of Luzon, though in Spanish days, some pretense was made to work some seams at Bacon in Sorsogón Province. At this place, the seams appear to be continuations of those on Batan Island. The Spanish engineers had opened up these seams with several hundred meters of galleries.

Coal has been found at several other places on the mainland, in the sub-province of Bontoc Ilocos Sur, Rizal, Bulacan and Tayabas, but either in too small seams, or in unfavorable localities.

However, on two islands, so near the Luzon coast as to be practically a part of that island, namely, Polillo and Batan, workable coal seams have been prospected and partially developed for some time.

Batan Island.—The East Batan mine, which is located on the East end of Batan Island, consists of several hundred feet of underground workings on a seam of coal about five feet thick. The main entry to this mine is about 1,500 feet long, and runs in on the coal seam, at an angle of 42° from the direction of dip. The dip of this seam varies between 10° and 13° . The coal is a sub-bituminous coal with lignite qualities.

The government has erected at this mine large coal pockets and the coal is being used in the island steamers. Some development work was carried on on the western end of this Island by the United States army in former years, but it has now been abandoned.

Polillo Island.—On the eastern side of Polillo Island which lies in turn on the eastern coast of Luzon, there are four, probably five, seams of a very fair grade of coal. Two of these, possibly only one, will be found to be advantageously worked. These seams are dipping at a moderate angle toward the coast, but near the center of the Island where the coal measures abut sharply against the igneous rock, the seams are highly inclined, and in some cases vertical.

The development work is now in progress in that district. This coal is of somewhat better grade than the Batan coal. Coal has been found of a poor quality in a number of other places on the Island of Luzon, namely in Cagayan Valley, in North Central Luzon and in the sub-province of Abra, but no development work has been carried on there.

IRON

As the next most important mineral resource, we shall consider iron. This mineral in small quantities is wide spread. It is usually found associated with the crystalline rocks of the eastern Cordillera. It has been found in noteworthy quantities, in two districts, near Angat Bulacan and on a small island in Mambulao Bay, Ambos Camarines. It is quite probable that there is a fairly continuous belt of this mineral following the Cordillera between its two points. Magnetic Surveys to determine this, are now in progress by the division of mines, Bureau of Science.

At Angat, the iron deposits appear to be of considerable extent, but diamond drilling will be necessary to prove this. The ore is a very hard bluish hematite, which is found in the crystalline rocks, and is probably a segregation due to the alteration of chalcopyrite, and other iron-bearing minerals in these rocks. The natives here have mined and smelted this ore in a crude way for over a hundred years. No flux is used and charcoal is the reducing agent. The most successful of these iron workers is a native woman, Dona Maria Fernando, who sells about 15,000 plow shares and points a year, throughout the neighboring provinces.

Several engineers have examined the deposit in Mambulao Bay and it is the general opinion that there is a commercial quantity at that point, which can be worked from sea-level.

OIL

Petroleum has been discovered in seeps at several points in the Bundoc Peninsula in Tayabas Province (see reports by Adams, Eddingfield and others in the Mineral Resources of the Philippine Islands) and one well has been sunk to a depth of 140 feet. As yet, there is no commercial production and none can be hoped for, till deeper wells are bored. The whole country-side in that region has

been plastered with claims, by speculators and others, totally ignorant of the business or who have no money to carry on the necessary operations properly.

With a view to opening up this field, the government has begun triangulation in the district and later, this will be followed by topographical and geological surveys.

The oil is very light, having a paraffin base. It has a beautiful, clear, cherry color. An analysis is as follows:

ANALYSIS¹ OF OIL FROM WELL, NEAR THE VIGO RIVER

Specific gravity of oil at 15°5 C.....	0.845
Initial boiling point.....	80 c.
First fraction, light oils, 70°-150° C.....	27.0 %
Second fraction, burning oil, 150°-300°.....	56.75 %
Residuum above 300° C. by diff.	16.25 %

The formations here are Tertiary sandstone, shales, and limestones, flexed into a broad gentle anticline, with minor flexures, faults, etc., and is more or less intruded by igneous rocks.

Oil has been reported from other localities in Luzon, the chief one being near Aliminis in Pangasinan Province, but examination by members of the Division of Mines revealed no trace of oil. The formations there are, however, favorable for the accumulation of oil.

GOLD

In the very earliest records wherein the Island of Luzon is mentioned, there is also a reference to gold. When Magellan reached Cebu in 1521, he heard accounts of gold in that part of Luzon, now known as Ambos Camarines.

The natives of that province have a very pretty legend about how on a certain time, a golden carabao comes out at night from one of the mountains and passes under the sea to a neighboring mountain and how the gold deposits are in some way, connected with that carabao.

For centuries, the natives have panned for gold in their crude way, not unlike the methods employed by all primitive peoples, and they have even gone so far as to construct a crude and very limited

¹ Analysis by G. F. Richmond, Bureau of Science.

dredge, capable of handling a half-ton of gravel and sand in a day. Not only did the Tagalogs, but all the tribes including the wild Igorots, pan gold and from nearly every stream in the island. I have never yet found a stream which did not carry some gold. This gold, won by the natives, usually finds its way into the hands of the Chinese traders, and consequently it is difficult to get even an estimate of how much is recovered annually, but I believe that one thousand ounces a month is a very conservative estimate.

In the early eighties of this century, there were scores of arrastres in operation in Ambos Camarines; but hardly a single one can now be seen. This method, with which all mining men are familiar and hence need not be described here, was introduced by Spaniards from Mexico, probably over two hundred years ago.

At the present time, there are only one or two arrastres working in the district.

Several attempts at mining on a large scale were made, prior to the American occupation, but all were futile. But with the inrush of American prospectors and renewed vigor and new hope in the country, the outlook for the mining industry became very bright.

The first modern stamp mill of any size was erected on the Benguet consolidated property and began operating in 1906, and in 1907, the first large dredge (New Zealand model) was placed on the Paracale River. There are now two dredges at work, one building and a fourth projected.

The mills have not been so successful, due to a variety of causes, chiefly inadequate capital and poor management. The lodes are of many kinds. In Benguet, they are usually quartz fissure veins in andesite, while some contact deposits between the sediments and andesite and diorite have been noted. The gangue is predominately quartz with or without calcite, manganese oxide, and rhodochrosite. The gold is in some veins free, but is usually found in the pyrite in a finely divided condition, so much so that the best method of treatment will consist of crushing in cyanide with stamps and fine grinding in tube mills.

In Paracale in Ambos Camarines, there is much more free gold and a large number of the veins are "stringers," which are very

tantalizing and have been the ruin of more than one over-enthusiastic miner. In these veins the gangue is mainly a cellular quartz. There is also enough zinc and lead to complicate the process of treating these ores. Very little manganese is to be seen in these veins and the striking fact to be noted here is this, that this is the best placer district so far found in the whole archipelago.

COPPER

Copper has been found in the form of arsenates and sulphides in the Mancayan-Suyoc district of the Mountain Province, Luzon and the Camarines. The best known deposit is that in the Mancayan-Suyoc district. Eveland¹ writes the following concerning this deposit:

In view of the fact that the entire region, with the exception of the one ore body of the Mancayan mine, is in an early stage of development, it is impracticable to treat the ore deposits in detail. It seems to be fairly conclusive, however, that the general type of vein in the district is a narrow quartz lead, carrying metallic sulphides, in some cases of copper, and generally with gold associated in a free state. These veins are in the Mancayan diorite which underlies the entire district. With the advent of the "trachyte" flow, metamorphic changes have taken place and the nature of the country rock is altered to a considerable degree.

Recent development work has shown this deposit to be rather in the nature of a stockwork, and it appears to me to be more extensive than was first thought to be the case.

¹ A. J. Eveland, *Bulletin No. 4*, Min. Bur. Manila (1905). For further data regarding the mineral resources of the Philippines the reader is referred to the annual bulletin *Mineral Resources of the Philippines*, issued by the Division of Mines, Bureau of Science, Manila, P.I.